NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 4.

NOTES

ON THE

OCCURRENCE OF BISMUTH ORES

IN

NEW SOUTH WALES.

BY

J. A. WATT, M.A., B.Sc.,

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Geological Survey of New South Wales,
Department of Mines and Agriculture,
Sydney, 7th September, 1898.

Sir,

I have the honor to submit for publication Report No. 4 of the Mineral Resources Series, entitled "Notes on the Occurrence of Bismuth Ores in New South Wales," by Mr. J. A. Watt, M.A., B.Sc., Geological Surveyor.

There have been in the past numerous inquiries at the Department of Mines in regard to the production of the various metals and ores of New South Wales, the different localities in which they are found, their uses, and particulars as to their mode of occurrence. Much time was consumed in answering these inquiries, more especially as it was necessary, in most cases, to refer to a number of Annual Reports in order to collect the information required.

With a view of making information in regard to the mineral wealth of the Colony more easily accessible to the public, and at the same time bringing it up to date, the idea was conceived of issuing a series of short monographs under the general title of "Mineral Resources," each of which should treat of a separate metal or ore.

The success which has attended the publication of the three first monographs on "Chromic Iron Ore," "Tungsten Ores," and "Gold Dredging," respectively, is proof that the mining community recognise the advantages of being able to obtain complete information in regard to any metal in a concise and handy form.

It is hoped that the present number, on Bismuth Ores, will be found as useful as those which have preceded it.

Other monographs are in course of preparation, and will be issued as soon as possible.

I have the honor to be, Sir,
Your obedient Servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for
Mines and Agriculture.

Notes on the Occurrence of Bismuth Ores in New South Wales.

CONTENTS.

I. Introduction.
II. Alphabetical List of the Localities in New South Wales from which Bismuth Ores have been recorded.

NOTE.—No claim is laid to originality as regards the contents of this paper. In writing the introductory portion liberal use has been made of text-books and scientific papers dealing with the subject; and in the remainder there is little more than may already be found in the Annual Reports of this Department. The information that was scattered through so many publications has been brought together, and thus made available for the use of those interested in this branch of the Mining Industry.

I.—INTRODUCTION.

Properties of Bismuth.—Bismuth is a comparatively rare metal of a silver-white colour, in which a distinctly reddish tinge is noticeable. This metal, which has a specific gravity of 9·83, melts at a temperature of 270° C. (507° F.).

On passing from the fused to the solid state, it increases considerably in volume; on this property, coupled with its low fusibility, many of the uses to which bismuth has been applied depend. Metallic bismuth is so brittle that it can be readily pulverised.

As to its chemical properties, we find that nitric acid, and a mixture of that with hydrochloric acid dissolve bismuth readily. From solutions so formed the bismuth is easily precipitated by the addition of a large quantity of water, or, better still, by pouring the solution into a large volume of water. From the nitric acid solution the bismuth is precipitated, by the method just described, as a basic nitrate, a white insoluble compound, which has been largely used as a cosmetic, and is somewhat extensively employed in medicine. From a solution obtained by the use of the mixed acids a white precipitate of the oxychloride is formed.

Chief Ores of Bismuth.—Bismuth occurs in nature principally as native or metallic bismuth; but with this are associated, especially in the upper portions of lodes where a process of oxidation has been going on, other compounds, such as the oxide and carbonate, which occasionally occur in sufficient quantities to be economically important.

The sulphide (Bismuthinite, Bi_2S_3) is also not an uncommon ore. It usually occurs massive, with a foliated or fibrous structure, and has a metallic lustre and lead-grey colour. The carbonate (Bismutite, $Bi_2O_3.CO_2.H_2O$) varies in colour from white to straw-yellow and yellowish green. The only other compound that it is necessary to mention here is the telluride (Tetradymite), a mineral of a steel-grey colour and metallic lustre.

The ores are almost without exception associated with other metallic minerals which are the primary object of the mining operations, the bismuth being treated as an accessory constituent of the ores.

Tests for Bismuth in Ores.—The ordinary bismuth ores are not difficult to identify, owing to their low fusing points. If the presence of bismuth is suspected in any mineral, a small piece of it should be placed on charcoal and the blowpipe flame applied to it. Should the mineral fuse easily, and the charcoal in the vicinity of the fused mass become coated with an incrustation which is orange-yellow while hot, and lemon-yellow when cold; and, moreover, if a metallic globule remains on the charcoal, which is brittle and does not mark paper, it may be safely concluded that a bismuth mineral is present.

As a corroborative test, a portion of the mineral might be powdered and heated with nitric acid, and a small portion of the solution poured into a large volume of water, when a white precipitate, or with small quantities a turbidity, announces the presence of bismuth.

A good test is the heating of a little of the mineral, previously powdered, with sulphur and a little iodide of potassium, when, if bismuth be present, a beautiful bright-red incrustation will be formed on the charcoal.

Antimony ores, which resemble those of bismuth in their easy fusibility, may be readily distinguished from the latter in that they give a white incrustation when heated on charcoal, and are insoluble in nitric acid.

Uses.—The uses that have been made of bismuth and its compounds are few, and, consequently, there is but a limited demand for the metal.

One of the most important applications to which the metal has been applied, is in the production of fusible alloys, whose valuable properties depend on their low fusibility and the phenomenon of expansion during solidification. Bismuth alone fuses at a very low temperature, viz., about 270° C., but some of its alloys fuse at much lower temperatures, much below that of boiling water.

The most important of these alloys are :—

	Bismuth.	Lead.	Tin.	Cadmium.	Melting-point.
Newton's Metal.. ...	8 parts	5 parts	3 parts	.....	94·5° C.
Rose's ,, ...	5 ,,	3 ,,	2 ,,	.....	91·6° C.
Wood's ,, ...	15 ,,	8 ,,	4 ,,	3 parts	68° C.
Fusible ,, ...	2 ,,	1 ,,	1 ,,	.....	93·7° C.

Alloys consisting of lead, tin, and bismuth, mixed in such proportions that the mixture fuses at some particular temperature above 100° C., have been employed for safety plugs for boilers, but it is said that they have been found untrustworthy owing to the separation of the more fusible components of the alloy, when the plugs have been subjected to continuous heating near its actual melting-point. Alloys have also been used in automatic sprinklers placed in the ceilings of buildings as a safeguard against fires. The apertures of the sprinklers are closed by plugs of the alloy, which melt when unduly heated, and thus allow the water to flow from the sprinklers.

Fusible alloys have been used in stereotyping, in obtaining copies of woodcuts, &c.

The basic nitrate of bismuth is used in medicine, and as a cosmetic; and this compound, as well as the oxide, is employed in the manufacture of a highly refractive glass, and to give a colourless iridescent glaze to the surface of porcelain. Other compounds are also somewhat extensively used as medicines.

Occurrence of Bismuth Ores in Nature.—Although bismuth ores are known to occur in many countries, the deposits of economic value are comparatively few. The chief European mines which furnish bismuth ores are those of Schneeberg, Altenberg, Annaberg, and Johanngeorgenstadt, in Saxony, which were, indeed, at one time the sole producers of these ores. In these mines the bismuth occurs chiefly in the native state; but the sulphide and the

carbonate are frequently present. At Schneeberg the bismuth ores occur in cobaltiferous veins. In the Austrian Erzgebirge, Bohemia, ores of bismuth are found in the argentiferous veins near Joachimsthal, and in tin-bearing deposits. At Rezhanya bismuth occurs as a telluride, associated with the tellurides of the precious metals. Austria, between the years 1869 and 1895, produced 9,638 metric tons of bismuth ore, nearly the whole of which went to the Saxon Works for treatment.

Prussia has produced small quantities of bismuth ore.

Important deposits of bismuth ore occur at Tasna and Chorolque, in Bolivia, which contain also tin and the noble metals. Bismuth occurs in these places in the native state, and as ochre and carbonate—the ores containing from 20 to 30 per cent. of bismuth.

The ores of Chorolque are found in porphyry, while those of Tasna are in slates. These mines are said to have enough ore in sight to supply the whole world for several years to come; but only sufficient is sent to the market to meet the small demand.

At Meymac, in France, bismuth ores were at one time obtained. They occurred there in a vein in granite, which contained wolfram and arsenical pyrites near the surface, and bismuth ores at greater depths.

Bismuth ores are known to occur in nearly all the Australian colonies; but they have been obtained in quantity only in Queensland and New South Wales. In Queensland, bismuth deposits exist at Mount Biggenden, Mount Shamrock, on the Percy River, and at Eukalunda. Between 1891 and 1895, inclusive, 452 tons of ore were exported from Queensland.

The great bulk of the bismuth of commerce comes from the Saxon Works at Schneeberg; a little also from Freiberg and Altenberg. Bismuth is also produced in England, where Australian and Bolivian ores are treated.

II.—Bismuth Ores in New South Wales.

Coming now to the more immediate object of this paper, an alphabetical list is now given of the localities in New South Wales from which bismuth ores have been recorded. Against the name of each place is given the information contained in the official records of the character of the ores, and their mode of occurrence at that place. The information here furnished is rather meagre. This arises from the fact that in the case of only two of the deposits have geological examinations been made; while the great bulk of our knowledge consists of the results of assays of samples sent to the Departmental Laboratory. This accounts for the absence of knowledge as to the exact localities from which many of the samples have been derived.

The late Mr. C. S. Wilkinson made an examination of the Kingsgate deposits in 1883, and in 1889 the Mount Mitchell deposits, near Glencoe, were reported on by Mr. W. Anderson.

The limited demand for the metal, and the manipulation of the market by a "Ring," are factors that have greatly retarded the development of our bismuth deposits.

Note.—The following abbreviations are made use of:—

D.L.—Departmental Laboratory attached to the Geological Branch.

A.R.—Annual Report of the Department of Mines and Agriculture; when the year is given, it means the Report for that year, which is published during the following year.

Bi.—Bismuth.

Au.—Gold.

Ag.—Silver.

The results of assays are always given in percentage of metallic bismuth, and in ounces, pennyweights, and grains of gold and silver per ton.

Adelong.—Picked specimens of quartz containing iron pyrites, mispickel or arsenical pyrites, and metallic bismuth from a reef in the vicinity of Adelong were assayed in the D.L. in 1879, and found to contain Bi. 5·6 per cent. Mr. Slee, Chief Inspector of Mines, has mentioned the association of iron, copper, and arsenical pyrites, as well as zinc blende, and galena in the richest quartz of the Adelong Gold-field.

Bombala, 20 miles west of.—In A.R. 1894, p. 56, an assay is given of a sample stated to have come from a locality 20 miles west of Bombala. As there is no other record of bismuth ore from this locality, while similar ore occurs at Whipstick, which is about an equal distance east of Bombala, it is very probable the sample came from there. It yielded Bi. 14·83 per cent., Au. 11 dwts. 20 grs., Ag. 7 dwts. 14 grs.

Broken Hill.—See Mount Gipps.

Captain's Flat.—See Norongo.

Cobar.—Nine samples of copper ore from the Great Cobar Copper Mine, assayed in 1878, were all found to contain bismuth. The amount of this metal present in the ores varied from 0·21 per cent. to 2·58 per cent., the average of the nine samples being 1·53 per cent. The presence of this bismuth caused some difficulty in the refining operations. An analysis of the refined copper made in 1878 showed it to contain 0·419 per cent. Bi.

Deepwater.—See Pye's Creek.

Dundee.—A sample of quartz, wolfram, and carbonate of bismuth from this locality was assayed in 1897, and gave Bi. 1·42 per cent.

Emmaville.—Several small pieces of native bismuth encrusted with oxidized products were received at the Curator's office in May of this year. These were said to have been obtained at a place 3 miles from Carpet-snake Creek, in the Emmaville district.

Ewingar.—See Solferino.

Germanton.—Two samples from this place were assayed in 1890; one consisting of quartz with sulphide and carbonate of bismuth yielded Bi. 6·49 per cent., and the other, consisting of quartz with felspar, mica, oxides of tin and molybdenum, and molybdenite, yielded Bi. 0·99 per cent.

Glen Creek.—Two samples purporting to come from Glen Creek, near Emmaville, were assayed in 1897; one, containing carbonate and sulphide of bismuth, gave Bi. 2·77 per cent., the other, consisting of arsenical pyrites with clay, gave Bi. 0·96 per cent.

Water-worn fragments of bismuth have been recorded (See Prof. David's Memoir on the Vegetable Creek Tin Mining Field, page 163) from near Taylor's veins, on the Glen Creek.

Glen Innes.—One of the earliest references to the occurrence of bismuth ores in this Colony is that by Mr. Martin, Warden for the district, in A.R. 1877, page 109, where he says: "On this eastern watershed (of the New England Table-land) bismuth has been found in many widely separated places, and in one instance traced to the lode." The Kingsgate deposits are in all probability referred to here. See Kingsgate.

Glencoe.—See Mount Mitchell.

Gulf.—Mr. Slee, Chief Inspector of Mines, reported in 1880 having seen metallic bismuth near the Gulf, Vegetable Creek.

Gumble.—In 1886 a crushed sample of mineral, which was said to have come from Gumble, near Molong, gave on assay Bi. 11·76 per cent. A lode, from which the above sample probably came, was found on private land between Gumble and Delaney and Kelly's Mine. It was 2 feet in width,

and a shaft 30 feet in depth was sunk on it. Samples from this lode were said to have yielded from 3 per cent. to 18 per cent. Bi., and 4 oz. silver per ton.

Highland Home, Parish of.—Lumps of native bismuth weighing a quarter of a pound, have been picked up near Burn's Reef, in Portion 3, Parish of Highland Home, County Gough. (See Prof. David's Memoir previously referred to.)

Hillgrove.—Three samples, said to have come from Hillgrove, were submitted for assay in 1891. Two consisted of quartz with a little carbonate of bismuth. One of them gave Bi. 12·11 per cent., Au. 4 dwts. 8 grs., and Ag. 3 oz. 18 dwts. 16 grs., and the other Bi. 3·37 per cent., Au. trace, and Ag. 1 oz. 12 dwts. 16 grs.

The third sample, which was a quartz-sand, which had been previously washed, contained a little carbonate of bismuth and cassiterite, and gave on assay Bi. 24·42 per cent., Au. 10 dwts. 21 grs., and Ag. 11 oz. 6 dwts. 11 grs.

Another sample from near Hillgrove, consisting of felspathic lode-stuff with galena, assayed in 1893, gave Bi. 4·74 per cent., Au. trace, and Ag. 6 oz. 17 dwts. 3 grs.

Hogue's Creek.—In his report* on the bismuth lodes near Glen Innes, Mr. Wilkinson mentions that "about 12 miles north from Glen Innes, and about 1 mile east from the Tenterfield road, several bismuth and tin-bearing quartz-veins have been discovered. These occur in a different manner from those at Kingsgate. They form irregular veins and masses of quartz traversing a fine-grained micaceous felsitic rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length of about 100 yards and a width of 15 yards, is traversed by a network of quartz-veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore (cassiterite), molybdenite, arsenical pyrites, and wolfram. In another place, about 100 yards from that last named, a mass of hard crystalline quartz, in size at the surface about 40 feet by 20 feet, has been opened for a few feet in depth. It contains bismuth and tin ores, together with a large quantity of wolfram.

"Besides this, two other small veins of quartz, yielding bismuth and tin ores, crop out close by. I do not consider that the vein-stuff here can be profitably worked for tin on account of the occurrence in it of so much wolfram; but for bismuth mining the prospects are encouraging, and the reefs should be further tested."

Kingsgate.—In this locality the most important of the known bismuth deposits of the Colony occur, and these have furnished the greater portion of the ore produced in the Colony.

Developmental work seems to have commenced at the mines on the Kingsgate Run in 1879, during which year a bulk sample of 8 cwt. of ore was raised and sent to Sydney. In A.R. 1880, page 143, Mr. Warden Martin gives the following particulars of the bismuth lodes at Kingsgate:—

"Although bismuth has been long known to exist in the district, mining for the ore is an industry only six months old, and was commenced at Kingsgate, 18 miles easterly of Glen Innes. Originally the land at this spot was taken up for tin, but indications showing that ores of bismuth were abundant, led to that metal being alone mined for. The lodes in which the ore is found are 6 to 8 feet wide, with an east to west bearing, and probably a north and south connection. There are many of them exposed on their bearing for

* Report on Auriferous Antimony Lodes at Hillgrove and Bismuth Lodes near Glen Innes. By C. S. Wilkinson. Ann. Rept. Dept. Mines N. S. Wales for 1883, pp. 154-155.

a length of about 10 chains. The matrix is quartz. The country is rough and wild and of granitic formation, backed by basalt-covered table-lands about 3 miles distant from the mine.

"The Manager of the Kingsgate Mining Co., in his report for the half-year ending 11th December, 1880, states that—

4½ tons of ore	...	containing 50 per cent. Bi.
30 „ of rock ore...		„ 5 to 10 per cent. Bi.
30 „ of slimes	...	„ 5 per cent. Bi.

and 2,000 tons quartz, by assay value £4 per ton, were won from the lode during the six months from an open cutting. Samples of native bismuth from this mine shown me weighed from 1 to 2 lbs. Four and a half tons of ore from this mine were forwarded for sale to London. . . ."

In the early part of 1883 these bismuth deposits, which are situated at Kingsgate, near Yarrow Creek, and about 16 miles east of Glen Innes, were geologically examined by Mr. C. S. Wilkinson, whose report* I append almost in full.

"The formations are granite and altered slate, forming rough, broken country, with valleys about 500 feet deep. The line of junction of the two formations is well defined, and the bismuth lodes occur in the granite in proximity to this line or within about 400 yards from it. The mode of occurrence of these so-called 'lodes,' is very remarkable; they are pipe-veins or oval masses of quartz of variable thickness, descending in a more or less vertical direction in the granite, as though well-like caverns of very irregular diameter had been formed in the granite and filled with quartz and metallic minerals. Thus in one lode in the Kingsgate Company's property two masses of quartz (which the manager, Mr. W. Yates, informed me were 30 feet apart at the surface), on being followed down, united and formed one large pipe-vein about 27 feet in diameter, and of irregular shape, from portions of it protruding here and there into the granite. Nests or bunches of bismuth ore (native bismuth, sulphide, carbonate, and oxide of bismuth) were obtained about these protruding portions as well as through the mass of quartz, and in order to take out the vein-stone, a large excavation about 60 feet by 40 feet has been made. The vein has only been sunk upon to a depth of 50 feet. The quartz is of a coarsely crystalline nature, and contains, in patches, a considerable quantity of molybdenite. The metallic bismuth and sulphide occur in the solid quartz, but the carbonate and oxide lie chiefly in the joint fissures in the quartz. Sometimes masses of native bismuth are found between crystals of quartz in the vein, and when removed the impress of the quartz crystals is well shown. Some splendid specimens, from 4 to 6 lbs. weight, from this mine were presented by the Company to the Mining and Geological Museum. . . . The largest mass of native bismuth found here weighed nearly 30 lbs.

"Other similar veins, but smaller, have been proved, though only for a few feet in depth; one contains much arsenical pyrites and hexagonal plates of molybdenite. An average sample of these sulphides gave on assay—

Metallic bismuth, 2·6 per cent.
Fine gold, at the rate of 8 dwts. per ton.
Silver, at the rate of 3 oz. 5 dwts. per ton.

"On portion 25, about half a mile north-west from here, another large pipe-vein is being opened. Near the surface it consists of a very ferruginous mass of quartz, about 13 feet by 9 feet, containing bismuth, arsenical pyrites, wolfram,

*Ann. Rept. Dept. Mines and Agric. for 1882, pp. 27-29; and for 1883, pp. 154-155.

and molybdenite. The screened vein-stuff is said to yield about 50 lbs. of bismuth ore per ton, which will probably be equal to about 1 per cent. of ore from the whole vein-stuff.

"A sample of the ore consisting of mixed particles of native bismuth, carbonate, sulphide, and oxide, yielded on assay—

Metallic bismuth, 69·3 per cent.
Fine gold, at the rate of 4 oz. 1¾ dwts. per ton.
Fine silver, at the rate of 57 oz. 3 dwts. per ton.

"The result of the assay of the ironstone from this vein was 0·6 per cent. of bismuth, and no gold; and the arsenical pyrites gave only a trace of gold and bismuth, with silver at the rate of 12 oz. 5 dwts. per ton. The gold, therefore, appears to be almost entirely contained in the bismuth ore, probably in the metallic portion of it.

"Several veins of a similar nature have been opened on the Glen Innes Company's property, which adjoins that of the Kingsgate Company. The Company is now sinking upon a vein which is said to have been 1 foot wide at the surface; but when I saw it at a depth of 40 feet (the lowest level then reached), it was 4 feet wide. This vein is in granite, and close to the boundary of the slate formation. The vein-stuff is thickly studded with large brilliant steel-grey plates of molybdenite, some of them being more than 3 inches in diameter. Nodules of native bismuth, larger than walnuts, with carbonate, sulphide, and oxide of bismuth, occur through the vein, and in greater quantity in places where the molybdenite becomes abundant. Another vein, situated about 100 yards from this, contains, besides bismuth ore and molybdenite, some arsenical pyrites, which latter yielded on assay 9·2 per cent. of metallic bismuth, fine silver at the rate of 92 oz. 14 dwts. per ton, and no gold.

"About 3 miles east from the Yarrow Creek head station, and about the same distance in a south-easterly direction from Kingsgate, is the Comstock Bismuth Company's Mine. No work was being done here at the time of our visit; but we saw three pipe-veins of hard white crystalline quartz which had been opened for only a few feet from the surface. The shafts were partly filled with water, so that the exact size of the veins could not be measured; but the largest of them appeared to be about 6 feet by 15 feet near the surface. A sample of bismuth ore collected from the heaps gave on assay—

Metallic bismuth, 35·6 per cent.
Fine gold, at the rate of 2 oz. 9 dwts. per ton.
Fine silver, at the rate of 9 oz. 16 dwts. per ton.

"Thus, again, we see that the bismuth ore contains gold. These veins are also in granite, and distant about 200 yards from the slate formation. It is a somewhat remarkable feature that all the bismuth veins (eighteen) as yet found occur in the granite, within a short distance from the slate; and it is probable that on further examination of the country along the line of junction of the two formations other veins will be discovered."

Molong, 25 miles from.—In 1889 a sample, said to have come from this locality, and consisting of quartz and carbonate of bismuth, gave Bi. 13·05 per cent.

Moor Creek.—See Tamworth.

Mount Dromedary.—A small vein, from a few inches to over a foot in thickness, has for many years been worked on Mount Dromedary. It traverses the granite forming that mountain in a nearly east and west direction. A sample from this vein yielded on assay Bi. 1·66 per cent., Au. 2 oz. 15 dwts. 12 grs., and Ag. 10 oz. 15 dwts. 19 grs.

Mount Emily, near.—In 1895 a sample of weathered granite from near Mount Emily and to the south of Quambi, containing bismuth ores, yielded Bi. 6·39 per cent., Au. 4 dwts. 8 grs., and Ag. 2 oz. 1 dwt. 9 grs.

Mount Gipps.—An assay was made in 1884 of a brown mineral with cavities filled with carbonate of bismuth, which was said to have come from Mount Gipps, 13 miles north of Broken Hill, in the county of Yancowinna, with the following result:—Bi. 14·55 per cent., Au. nil, Ag. 4 oz. 18 dwts., and traces of copper and cobalt.

Mount Mitchell.—Three samples of ore from this locality were assayed in 1888; two of them, consisting of quartz and carbonate of bismuth, contained respectively Bi. 5·91 per cent. and 1·44 per cent. The third was a concentrated sample and consisted of quartz, carrying native, oxide, and carbonate of bismuth. This yielded on assay Bi. 62·0 per cent., Au. 4 oz. 11 dwts. 10 grs., and Ag. 1 oz. 1 dwt. 16 grs.

These bismuth deposits of Mount Mitchell, near Glencoe, were geologically examined in 1889 by Mr. W. Anderson, whose report* is given almost in full.

"The position of these bismuth-bearing veins is in the north-west corner of the parish of Coventry, county of Clarke, and is about a mile to the south-east of Mount Mitchell. The bismuth ores occur distributed in small irregular patches through a series of quartz-veins averaging from half an inch up to 4 inches in thickness. The quartz is clear and translucent and towards the centre of some of the veins is crystalline, the pyramidal apices of the crystals from opposite sides of the veins interlocking in the centre. The contained bismuth ore is in the form of oxide, sulphide, and carbonate of bismuth, which in many cases are found to cover a central nucleus of metallic bismuth. The veins traverse a ternary granite, whose general texture and mineral constituents vary very much. Their strike is south-west and north-east, and they pass downwards in a nearly vertical direction, with a slight inclination to each other, as if they would unite at a lower depth. Their outcrop can be traced for a considerable distance along the surface, and small quantities of bismuth can be washed from the soil in the immediate neighbourhood of the outcrop. The veins contain a fair percentage of free gold. Little or no work has yet been done in opening up or proving the extent of the bismuth-bearing veins. A couple of holes have been sunk, averaging about 10 feet deep. The mode of occurrence of the bismuth ores here differs slightly from that at the Kingsgate mines, in that at the latter place they occur in pipe-veins near the junction of the granite with the slate, while here they are found in quartz-veins traversing the mass of the granite. Of two assays made of the quartz, one returned 5 per cent. of metallic bismuth, with traces of gold, and the other showed traces of metallic bismuth. . . . It will no doubt be found, on proving these veins, that they are more or less lenticular in shape, thickening and thinning out, and running together in a very irregular manner, although probably on the same vertical line. They do not present, so far as one can judge from their present development, the same prospects of such large quantities of bismuth ore being obtained as in the case of the pipe-veins of Kingsgate."

Nanima.—Auriferous bismuth ores occur in quartz-veins at Nanima, 3 miles east of Murrumbateman in the Yass district. There are several reefs in that locality, some of them 3 or 4 feet wide, which run in a north and south direction and underlay to the east. A sample collected by Mr. E. C. Whittell gave on assay Bi. 6·37 per cent., and Au. 1 oz. 7 dwts.

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* Ann. Rept. Dept. Mines and Agric. for 1889, p. 231.

Nimitybelle.—Bismuth ores were found near Nimitybelle, in the Southern district, in 1888, in which year a sample consisting of quartz and sulphide of bismuth was assayed, and found to contain Bi. 3·67 per cent. An area of 79 acres was taken up with the object of mining for this metal. Since 1888 several samples of the ore, which consist of sulphide of bismuth, with quartz as a veinstone, have been assayed in the D.L., and have given returns varying from 2·71 per cent. to 8·81 per cent. Bi.

Norongo.—Telluride of bismuth was found at Norongo, 8 miles south of Captain's Flat, in 1888, and samples were forwarded to this Department for assay. Two samples, consisting of carbonate of bismuth and tetradymite, were assayed ; one was found to contain 19·26 per cent. of metallic bismuth, and the other 27·88 per cent. of bismuth and 10·42 per cent. of tellurium. A third sample consisted of clay, with carbonate of bismuth and tetradymite, and contained 16·9 per cent. of bismuth, a trace of gold, 2 oz. 3 dwts. 13 grs. of silver per ton, and 7·04 per cent. of tellurium. Another sample, consisting of carbonate and sulphide of bismuth, gave 60·2 per cent. of bismuth.

The chemical composition of the telluric-bismuth ores from this locality has been described in some detail by Mr. Mingaye,* who gives the following particulars of the occurrence of the ores :—"The mineral was discovered at Norongo, about 8 miles south of Captain's Flat, in a gossan lode about 16 feet wide, through which runs the vein containing the mineral, the latter being 6 inches in width, and occurring at a depth of about 2 feet from the surface."

The physical character of these ores were described by Prof. David,† who identified the following minerals :—tetradymite, montanite, and telluric-bismuthic ochre. The two latter surround nuclei of tetradymite, and evidently owe their origin to the alteration of the tetradymite.

Nymagee.—In 1895 it was reported that very promising indications of the existence of payable deposits of bismuth were met with in the Nymagee district. No steps have, I believe, been taken to open up these deposits.

Oban.—Two samples from this locality were assayed in 1889 ; one, consisting of native bismuth, carbonate and oxide of bismuth, gave Bi. 75·60 per cent. and Au. 2 oz. 7 dwts. 21 grs., and the other, a friable earthy carbonate of bismuth, yielded Bi. 10·04 per cent. A third sample was assayed in 1891 ; this consisted of quartz and felspathic gangue, with molybdenite, and yielded Bi. 1·45 per cent., Au. 4 dwts. 8 grs., and Ag. 2 dwts. 4 grs. These samples may possibly have come from the Mount Mitchell deposits.

Orange.—A sample of bismuth ore, said to have come from the vicinity of Orange, was assayed in 1882, and gave Bi. 5·4 per cent. and Ag. 4 oz. 2 dwts.

Pye's Creek.—In one of the veins on Pye's Creek, in the parish of Annandale, county Clive, bismuth is reported to have been discovered in some quantity. (See Prof. David's Memoir previously referred to.) A 40-acre block next to Hamilton & Co.'s lease was taken up for the purpose of mining for this metal. In 1885 three samples of bismuth, bearing material from Pye's Creek, were assayed with the following results :—

(1) Ferruginous quartz and metallic bismuth from 40-acre block adjoining Hamilton and party's lease gave Bi. 66·8 per cent., and Ag. 33 oz. 8½ dwts.

(2) Ferruginous quartz with metallic bismuth and carbonate of copper from the same locality yielded Bi. 3·9 per cent., and Ag. 200 oz. 18 dwts.

(3) Ferruginous sand and galena and a little carbonate of copper from the same place gave Bi. 13·3 per cent., and Ag. 166 oz. 12 dwts.

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* Records Geol. Surv. N. S. Wales, Vol. I, pt. 1 pp. 26-28.
† Records Geol. Surv. N. S. Wales, Vol. I, pt. 1, pp. 29-30.

Silent Grove.—The Chief Inspector of Mines reported (A.R. 1880, page 220) the existence of a lode 8 inches in thickness at Silent Grove, in the Vegetable Creek district, on the property belonging to Mr. Alexander Stuart, of Sydney. The bismuth lode in this locality occurs under the same conditions as those at Kingsgate, viz., in granite close to its junction with altered slates.

Prof. David, in his Memoir on the Vegetable Creek Tin-mining Field, page 163, mentions that bismuth "has been found native, and as carbonate and sulphide associated with tin-stone and quartz, in portion 15, parish of Silent Grove, county Clive. The total width of the vein is about 1 foot, and its strike 15 degrees south of east and north of west, with a northerly dip. The bismuth is distributed through the quartz chiefly in acicular crystals, and lies next to the foot-wall; the thickness of the bismuth-bearing part of the vein is 4 inches."

Slippery Creek.—Telluride of bismuth was found by Mr. E. C. Whittell, Field Assistant, at Mitchell and Party's claim, near Slippery Creek, in the Oberon district. Mr. Card,* who identified the mineral, writes as follows:—"It occurs along with free gold in small grains and flakes in the quartz, and is associated with greenish and yellowish alteration products. The telluride is probably auriferous."

Solferino.—A sample of brown iron ore from this district near Ewingar was assayed in 1890, and found to contain carbonate of bismuth yielding Bi. 69·95 per cent., and Ag. 2 oz. 5 dwts. 17 grs. Another from the same place, consisting of brown iron ore with a little oxide of bismuth, gave Bi. 0·63 per cent.

Sunny Corner.—Small quantities of bismuth have been found in the ore of the Sunny Corner Mine. An analysis is quoted by Mr. C. S. Wilkinson in his report on that mine (A.R. 1886, page 140), in which 0·88 per cent. Bi. was found in the ore.

Tamworth.—Telluride of bismuth has been recorded from Moor Creek and Sawpit Gully.

Tent Hill.—A sample of decomposed micaceous rock from this locality assayed in 1897 gave Bi. 3·46 per cent.

Tenterfield.—Two samples of bismuth-bearing material were sent in 1879 to the D.L. for assay; one, a yellow ochreous mass, consisting of carbonate and oxide of bismuth associated with quartz and molybdic oxide, stated to have come from Tenterfield, was found to contain Bi. 43·29 per cent., and 6·6 per cent. of molybdenite. The other, said to have been derived from a reef 4 feet wide, occurring near Tenterfield, consisted of metallic bismuth, carbonate of bismuth, and molybdic sulphide and oxide in a matrix of quartz; this yielded on assay Bi. 60·09 per cent., Au. 1 oz. 4 dwts. 10 grs., and Ag. 8 dwts. 10 grs.

In 1889 a sample of quartz with oxide of bismuth gave on assay Bi. 2·72 per cent.; and in the following year a sample of compact felsite with oxide of tin, magnetic iron ore, and a little carbonate of bismuth, yielded Bi. 1·50 per cent.

Tingha.—Samples of bismuth ore have been forwarded from time to time from Tingha for examination. In 1878 waterworn nodules of carbonate and oxide of bismuth, white to dark-brown in colour, were assayed by Mr. Dixon, and found to contain Bi. 60·43 per cent. Rolled fragments of the same, associated with talc and ferric oxide, contained Bi. 62·75 per cent.

Land was taken up in 1885 in the remote south-west portion of the Tingha Division, for the purpose of mining for bismuth ore.

* Records Geol. Surv. N.S. Wales, 1897, V., Pt. 2, p. 66, Mineralogical Notes by G. W. Card, A.R.S.M.

Two samples of material, stated to have come from Tingha, were assayed in 1887; one, consisting of quartzite with metallic bismuth, contained Bi. 0·35 per cent.; and the other, an artificially concentrated sample of native bismuth and its oxide, gave Bi. 76·62 per cent. In the following year two more samples from the same locality, consisting of ferruginous quartz, with native, oxide, and carbonate of bismuth, were assayed; one gave Bi. 5·36 per cent., and Au. 13 dwts. 6 grs.; and the other Bi. 1·06 per cent., but no gold.

Uralla.—Telluride of bismuth has been recorded by Mr. Card, from Kentucky Run, near Uralla, where it occurs in association with free gold in a white quartz.

Whipstick.—Rich argentiferous bismuth ores have been obtained in the Great Jingera Silver Mine, which is situated 10 miles west of Pambula and 4 miles east of Wyndham. Mr. Warden Maunsell wrote in 1891 as follows:—"The lodes here consist of soft granular felspar matrix, impregnated with blotches of bismuth, molybdenum, and chloride of silver. They are capped with granitic rock, containing a large percentage of manganese, white mica, and garnets. The country rock consists of quartz, felspar, white mica coarsely crystalline. . . . The Great Jingera Proprietary Silver-mining Company hold eight leases for an area of 203 acres. It is opening up the lode in several places. From an outcrop on mineral lease No. 4 it has despatched 4 tons of ore, averaging 1,170 oz. of silver to the ton, and from 3 to 10 per cent. of bismuth. The mine is situated on the summit of the North Jingera Range, about 1,500 feet above sea-level."

In 1892 the Great Jingera Silver-mining Company sent away to Europe 31 tons of argentiferous bismuth ore, which gave a return of 3½ tons of bismuth, 12 oz. of gold, and 6,107 oz. of silver, of a total value of £2,343.

In the A.R., 1897, page 42, it is pointed out that 1,430 tons of ore were raised during that year, of which 146 tons were sold and exported. The estimated value of the bismuth sold was £3,100, and that of the silver associated with the bismuth, £264.

Wyndham.—See Whipstick.

Yarrow Creek.—See Kingsgate.

Production of Bismuth Ore in New South Wales between 1879 *and* 1897.

Year.	Yield.	Value.	Year.	Yield.	Value.
1879 ...	0·40 tons	.....	1889 ...	42·50 tons	£11,349
1880 ...	4·5 „	.....	1890 ...	2·10 „	306
1881 ...	12·5 „	£2,728	1891 ...	0·4 „	500
1882 ...	2·7 „	162	1892 ...	14·0 „	1,080
1883 ...	3·7 „	650	1893 ...	.. ...	... ..
1884 ...	14·37 „	2,770	1894 ...	.....	.....
1885 ...	14·0 „	3,700	1895 ...	.....	.....
1886 ...	20·9 „	3,870	1896 ...	41·0 „	490
1887 ...	36·55 „	6,695	1897 ...	3·1 „	800
1888 ...	18·07 „	3,911			

Sydney: William Applegate Gullick, Government Printer.—1898.